

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
27 November 2003 (27.11.2003)

PCT

(10) International Publication Number
WO 03/097478 A1

(51) International Patent Classification⁷: **B65D 51/28**,
81/32, A23L 2/52, A61K 33/26, 33/30

(21) International Application Number: PCT/US03/15423

(22) International Filing Date: 15 May 2003 (15.05.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10/150,328 16 May 2002 (16.05.2002) US
10/247,190 19 September 2002 (19.09.2002) US
10/367,006 14 February 2003 (14.02.2003) US

(71) Applicant: **THE PROCTER & GAMBLE COMPANY**
[US/US]; One Procter & Gamble Plaza, Cincinnati, OH
45202 (US).

(72) Inventors: **DANIELS, Jacqueline, Ann**; 80 Fawn Drive,
Apt. 207, Fairfield, OH 45014 (US). **MEHANSHO, Haile**;

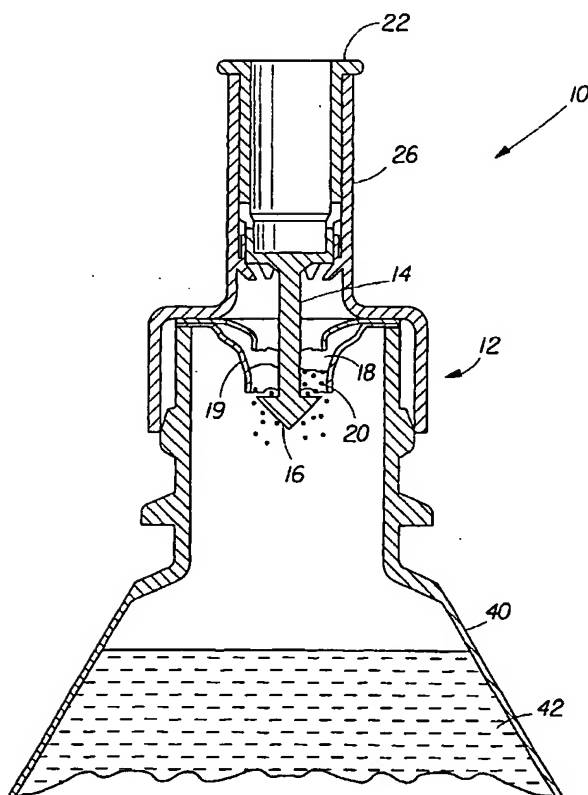
7 Highknoll Court, Fairfield, OH 45014 (US). **NUNES, Raul, Victorino**; 173 Shoemaker Drive, Loveland, OH 45140 (US). **MILLER, Christopher, Miles**; 5449 Carterway Drive, Milford, OH 45150 (US). **WEAVER, Kerry, Lloyd**; 7213 Carolyn Court, Florence, KY 41042 (US).

(74) Agents: **REED, T., David et al.**; The Procter & Gamble Company, 6110 Center Hill Rd., Cincinnati, OH 45224 (US).

(81) Designated States (*national*): AE, AG, AL, AM, AT (utility model), AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ (utility model), CZ, DE (utility model), DE, DK (utility model), DK, DM, DZ, EC, EE (utility model), EE, ES, FI (utility model), FI, GB, GD, GE, GH, GM, *HR*, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK (utility model), SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW.

[Continued on next page]

(54) Title: MINERAL FORTIFICATION SYSTEMS FOR ADDING MINERALS TO BOTTLED, POTABLE LIQUIDS



(57) Abstract: A mineral-fortification system that has a bottle cap, a pouch and a pouch opener. A powder is contained within the pouch, and the powder contains at least one mineral and a redox modulating compound. When the cap is secured onto the opening of a bottle containing a liquid and when the pouch opener is activated, the powder is released from the pouch and mixes with the liquid to form a mineral fortified liquid composition that is fortified with at least one mineral and has a pH between about 2.5 and 9.5. Moreover, the mineral fortified liquid composition has a redox potential that satisfies the following equation: $0.3 \text{ RP} - (A - B \cdot \text{pH})$. In this equation RP is the redox potential in millivolts of the mineral-containing liquid composition, pH is the pH of the mineral-containing liquid composition, A is 400 and B is 20. The mineral is preferably selected from calcium, iron, zinc, copper, manganese, iodine, magnesium, and mixtures of these. Moreover, the mineral-fortified liquid composition may preferably be substantially free of flavor or sweetener compounds. Even more preferably, the liquid composition has no metallic taste or after-taste, a Hunter colorimetric "b" reading of less than 5.0, and an NTU turbidity value of less than 5.0. The mineral-fortified liquid composition may optionally contain other nutrients and vitamins, for example, vitamin A, vitamin C, vitamin E, niacin, thiamin, vitamin B6, vitamin B2, vitamin B12, folic acid, selenium, pantothenic acid, and iodine.

WO 03/097478 A1



(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

MINERAL FORTIFICATION SYSTEMS FOR ADDING MINERALS TO BOTTLED, POTABLE LIQUIDS

TECHNICAL FIELD

The present invention relates to mineral fortification systems comprising a powdered mineral fortification composition contained within a cap that can be attached to a bottle of liquid. After the cap is attached, the minerals can be released from the cap allowing the minerals to mix with and fortify the bottled liquid. The mineral used in the present fortification systems include minerals such as calcium, iron, zinc, copper, manganese, iodine, magnesium, and mixtures thereof, or mixtures of two or more of these compounds that have excellent bioavailability. The resulting fortified liquid containing the minerals, especially iron and zinc compounds, does not have an off-flavor/aftertaste, is stable, and overcomes the problem of discoloration, precipitation and/or poor bioavailability caused by the addition of these minerals to a liquid. The compositions can also optionally include vitamins, and other nutrients.

BACKGROUND OF THE INVENTION

In many countries, the average diet does not contain sufficient levels of necessary minerals and nutrients, such as, iron, zinc, iodine, vitamin A or the B vitamins. Iron deficiency is well documented. Iron deficiency is one of the few nutritional deficiencies in the U.S., and it is common in most developing countries. Recent evidence suggests that nutritional zinc deficiency may be common among the people of many developing countries where they subsist on diets of plant origin (e.g. cereal and legume). Marginal mineral deficiencies may be widespread even in the U.S. because of self-imposed dietary restrictions, use of alcohol and cereal proteins, and the increasing use of refined foods that decrease the intake of trace minerals.

Many mineral deficiencies can be overcome by taking supplements. Other methods of addressing these deficiencies include increasing the intake of foods naturally containing these minerals or fortifying food and beverage products. Usually, in countries where the people suffer from these deficiencies, the economy is such that providing minerals and vitamins as a supplement is expensive and presents significant distribution logistics problems. In addition, compliance, i.e., having the people take the vitamin and mineral supplements on a daily basis, is a serious problem. Accordingly, the delivery of minerals along with other vitamins and nutrients in a form that has high bioavailability and at the same time a non-objectionable taste and appearance, and in a form that would be consumed by a high proportion of the population at risk is desirable.

Vitamin and mineral fortified beverages and foods are known. Although substantial progress has been made in reducing iron deficiency by fortifying products such as infant formulas, breakfast cereals and chocolate drink powders, the formulations require milk that is often not available or affordable. To address the problem of iron and zinc deficiencies in the general population, efforts have been directed to formulating fruit-flavored dry beverage mixes supplemented with nutritional amounts (i.e., at least 5% of the USRDI) of zinc and iron with or without vitamins. Many fruit-flavored powdered beverages contain vitamins and/or minerals but seldom contain both zinc and iron at any significant level, see for example, Composition of Foods: Beverages, Agriculture Handbook No. 8 Series, Nutrition Monitoring Division, pgs 115-153.

There are well-recognized problems associated with adding both vitamins and minerals to beverages. Zinc supplements tend to have an objectionable taste, cause distortion of taste and cause mouth irritation, see for example U.S. Patent 4,684,528 (Godfrey), issued August 4, 1987. Iron supplements tend to discolor foodstuff, or to be organoleptically unsuitable. Moreover, it is particularly difficult to formulate products containing minerals and, in particular, mixtures of bioavailable iron and zinc. These minerals not only affects the organoleptic and aesthetic properties of beverages, but also undesirably affects the nutritional bioavailability of the minerals themselves and the stability of vitamins and flavors.

Several problems exist with delivering a mixture of iron and zinc with or without vitamins in a beverage mix. A few of the problems are choosing iron and zinc compounds which are organoleptically acceptable, bioavailable, cost effective and safe. For example, the water soluble iron and zinc compounds, which are the most bioavailable cause unacceptable metallic aftertaste and flavor changes. In addition, the soluble iron complexes often cause unacceptable color changes. Even further, the iron complexes themselves are often colored. This makes formulating a dry powder that has a uniform color distribution in the mix more difficult. Often the reconstituted beverage does not have a suitable color identifiable with the flavoring agent. If the color of the powder, reconstituted beverage or flavor of the beverage is substantially altered, the beverage will not be consumed. Color and taste are key to consumer acceptance.

Many iron sources that have been successful commercially, have been found to be unsatisfactory for use herein. For example, U.S. Patent 4,786,578 (Nakel et al.), issued November 1988, relates to the use of iron-sugar complexes suitable for supplementing fruit beverages. While this supplement may produce an acceptable taste in certain fruit flavored beverages, the supplement causes discoloration and consumer detectable differences in some colored beverages. Iron sources typically used to fortify chocolate milk were also found undesirable due to color problems and/or flavor problems.

It has further been found that iron is more bioavailable if administered in the form of chelates wherein the chelating ligands are amino acids or protein hydrolysates. See, for example, U.S. Patent 3,969,540 (Jensen), issued July 13, 1976 and U.S. Patent 4,020,158 (Ashmead), issued April 26, 1977. These chelated iron compounds are known in the art by various names such as iron proteinates, iron amino acid chelates and peptide or polypeptide chelates. These will be referred to herein simply as "amino acid chelated irons." A particularly desirable amino acid chelated iron is FERROCHEL made by Albion Laboratories. FERROCHEL is a free flowing, fine granular powder that provides a high bioavailable source of ferrous iron that is typically complexed or chelated with the amino acid glycine.

Unfortunately, it has also been found that FERROCHEL, when added to water or other aqueous solutions, imparts relatively quickly a deep rusty yellow color. Such a color can change the color appearance the food or beverage to which FERROCHEL has been added. In the case of many foods and beverages, this color change would be unacceptable. It has been found that FERROCHEL causes unacceptable off-color development in various foods and beverages by interacting with dietary components such as the polyphenols and flavonoids. Furthermore, by accelerating the oxidative rancidity of fats and oils, FERROCHEL (like ferrous sulfate) has been found to cause off-flavor in foods and beverages.

One solution to delivering a mineral-fortified beverage is disclosed in PCT Publication WO 98/48648 (The Procter & Gamble Company), published November 5, 1998, which teaches a dry free-flowing beverage composition that when reconstituted with water has a desirable color and is free of undesirable aftertaste. The dry free-flowing beverage composition contains from about 5% to about 100% of the USRDI of iron, optionally from about 5% to about 100% of the USRDI of zinc, from about 0.001% to about 0.5% of a coloring agent, and from about 0.001% to about 10% of a flavoring agent. An edible acid sufficient to lower the pH to between 3 and 4.5 in the finished beverage is added. As can be appreciated, some of the additives are nutrients, while others are used to mask the taste and off-color caused by adding minerals to an aqueous solution.

An even greater challenge has been faced in providing a mineral fortified drinking water that contains a bioavailable source of iron or zinc mineral. A drinking water, as opposed to a beverage, should contain water as its main ingredient, and which should have the taste and appearance of pure water. Fortification of drinking water with soluble, stable and bioavailable minerals (e. g. iron, zinc) has been a challenge. For instance, when the soluble form of iron (ferrous iron) is added to regular water, it rapidly oxidizes to the insoluble trivalent form, which is ferric iron. Subsequently, the ferric iron combines with hydroxide ions to form iron hydroxide (yellow colored), which later converts to ferric oxide, a red, powdery precipitate called "rust." Thus, it is well known fact that natural water not only oxidizes iron from ferrous to ferric

moieties, but also causes (a) the development of undesirable color (yellowish-rusty), (b) poor solubility demonstrated by precipitation and increased turbidity, (c) compromised bioavailability and (b) co-precipitation of other minerals (e. g. zinc, magnesium, calcium) and phosphate.

The behavior of such nutritionally important minerals in natural water (e. g. lakes, streams, rivers and oceans) is due to the oxidizing nature of the natural water. Most fresh water and lakes have a pH range from pH 5 to about 9. Furthermore, they contain not only dissolved oxygen but also other electron accepting species (iron-oxidizing) such as nitrates, manganese (IV), chloride ions. Both the pH range and the presence of the electron accepting species makes natural water an oxidizing media. Thus, it favors poor solubility, off-color development and compromised bioavailability and stability. In fact, the ability (tendency) of natural water to act as an oxidizing media is determined by measuring the Redox potential (Eh) in millivolts (mV). The redox potential for the different species of iron is defined by (a) *Eh-pH diagram* and (b) *Nernst's equation: $Eh = Eo + 0.059/n \log [\text{oxidized species}]/[\text{reduced species}]$* , where Eh = observed electrode potential, Eo = standard electrode potential, n= number of electrons transferred. Under normal condition, water has relatively high redox potential (>300 mV), which is an indicator of highly oxidizing environment. This is primarily due to the presence of various electron acceptors (oxidizing agents), which include ozone, chlorine, oxygen, nitrates and manganese (IV).

Hence, there is a tendency for iron to turn rusty and precipitate as a result of the oxidizing nature of the water, and to develop a metallic off-taste that is attributed to free iron ions in the water. Since drinking waters should not have perceptible flavors or colors, the development of unacceptable iron coloration, poor solubility, or metallic taste in a drinking water cannot be masked over.

Attempts to provide an iron-containing drinking water in the past have shown limited success. FR Patent publication 2,461,463, published February 6, 1981, discloses a procedure for preparing and stabilizing an iron-containing mineral water by adding an ascorbic acid, or salt thereof, reducing agent, where the weight ratio of ascorbic acid to ferrous ion is from about 2.5-6.5. The reducing agent is added to reduce any ferric ions to the ferrous state, which was believed to be the active bioavailable state of iron.

Further, German Patent No. 19,628,575, published January 29, 1998, discloses drinking water or mineral water such as coffee, fruit teas or soft drinks, containing ferrous iron and an excess of organic or inorganic dietary acids to reduce the water pH to the range of 2-5. Iron gluconate and iron sulfate were disclosed as the added iron source. The resulting acid flavor of these waters was then neutralized by the addition of flavors, sugar and/or sweetener.

The benefits provided by mineral fortified liquid compositions are clear, but providing these compositions to consumers presents many problems. Specifically, it is often not desirable or economical to prepare, bottle, ship, store and sell a fortified liquid. One such problem is that the minerals and other nutrients can promote the growth of undesirable bacteria and other microbials. Preservatives can be added to the liquid to slow this gradual contamination problem. But preservatives add cost and are often viewed by consumers as unnatural and therefore contradictory to the concept of drinking a healthy beverage. Thus, it would be far more desirable if the consumer of such a product could prepare the beverage themselves using their own liquid composition.

Accordingly, there exists a need for a mineral fortification system that allows consumers to prepare a mineral fortified liquid composition near to the time and place that the mineral fortified liquid composition is to be consumed. This system should provide the mineral along with any necessary stabilizing compounds, such as a redox modulating composition, in an easily dispensable form. Preferably this form is compatible with a common bottle, such as a juice, water or milk bottle, allowing the consumer to combine the mineral fortification powder with a preexisting bottle of liquid. Or the bottle, liquid and powder could be sold together but unmixed so that the consumer can mix a fresh compositions at any desired time. It is preferred that the liquid compositions produced by the desired mineral fortification system have no metallic taste or aftertaste, without the use of any flavor or sweetener. Likewise, it is desired that these compositions have an acceptable clarity and color, and preferably they are clear and colorless. These and many more advantages are provided by the present invention.

SUMMARY OF THE INVENTION

In one aspect of the present invention there is provided a mineral-fortification system comprising:

- a) A bottle cap comprising a pouch and a pouch opener;
- b) A powder contained within the pouch, the powder comprising at least one mineral and a redox modulating compound.

Further, when the cap is secured onto the opening of a bottle containing a liquid and when the pouch opener is activated, the powder is released from the pouch and mixes with the liquid to form a mineral fortified liquid composition. This composition is fortified with at least one mineral and has a pH between about 2.5 and 9.5, and the mineral fortified liquid composition has a redox potential that satisfies the following equation:

$$0 \geq RP - (A - B \cdot pH).$$

In this equation, RP is the measured redox potential in millivolts of the mineral fortified liquid composition, pH is the pH of the mineral fortified liquid composition, A is 400 and B is 20, preferably, A is 380 and B is 18, more preferably A is 360 and B is 16, and even more preferably A is 340 and B 14. The mineral is preferably selected from the group consisting of calcium, iron, zinc, copper, manganese, iodine, magnesium, and mixtures thereof.

In another aspect of the present invention there is provided a mineral-fortification system further comprising a bottle containing a liquid. Preferably, the liquid comprises at least about 90%, preferably at least about 95%, and more preferably at least about 99%, by weight, water.

In a yet another aspect of the present invention there is provided a mineral-fortification system comprising a bottle cap comprising a pouch and a pouch opener wherein the pouch opener comprises a blade that cuts into and opens the pouch when the cap is twisted onto a bottle. In another aspect the pouch opener comprises a plunger that opens the pouch when it is pressed down and through the pouch. Preferably, the cap further comprises a removable retaining ring that protects the pouch from being opened prematurely.

In another aspect of the present invention the mineral-fortified liquid composition produced by the mineral fortification system of the present invention is substantially free of a flavor or sweetener compound, and has: no metallic taste or after-taste; a Hunter colorimetric "b" reading of less than 5.0; and an NTU turbidity value of less than 5.0, preferably less than 2.0. Preferably, the mineral is either water soluble or a water-dispersible compound having a dispersed particle size of less than about 100 nanometers.

In yet another aspect of the present invention the mineral-fortified liquid composition may further comprise less than 4 ppm oxygen, preferably less than 3 ppm oxygen, and more preferably less than 2 ppm oxygen, and even more preferably an oxygen scavenging agent is provided. The mineral-fortified liquid composition may be substantially free of a redox potential increasing agent selected from an oxoanion salt, a halide gas and an organic material.

In one preferred embodiment of the present invention the mineral-fortified liquid composition further comprises an additive selected from the group consisting of vitamin A, vitamin C, vitamin E, niacin, thiamin, vitamin B6, vitamin B2, vitamin B 12, folic acid, selenium, pantathonic acid, iodine and mixtures thereof.

In yet another aspect of the present invention there is provided a packaged liquid, comprising: a mineral-fortified liquid composition according to the present invention; and an oxygen-barrier package.

The inventors have surprisingly found that minerals, for example, ferrous ions (Fe^{2+}), can be stabilized through redox modulation. The invention includes converting the natural water redox potential from "oxidizing/electron accepting" to "reducing/electron donating" by reducing the concentration of, and preferably eliminating, compounds/species that have higher redox potential than that of the added minerals. These include ozone, oxygen, hypochlorite, chlorine, nitrate/nitrite and manganese (IV).

A system has been developed that incorporates the present redox modulation technology for stabilizing minerals in liquid compositions into a delivery system that allows the composition to be mixed and consumed fresh. This system is superior to other mineral fortification systems in that the consumer can prepare the fortified liquid by simply combining the cap, and mineral containing pouch with a bottle of liquid. The convenient pouch opener is used to open the pouch dispersing the mineral powder into the liquid. With a slight amount of agitation, the mineral-fortified liquid composition is made and ready to drink. The resulting liquid composition contains minerals but at the same time has acceptable taste and leaves no undesirable aftertaste while the stability and bioavailability of the mineral is uncompromised. This invention has also been found to make liquid compositions that contain particular mineral sources having substantially clear and colorless appearance.

BRIEF DESCRIPTION OF THE DRAWINGS

While the present invention is defined by the claims herein, it is believed that these claims will be better understood with reference to the drawings wherein:

Figure 1 is a mineral-fortification system according to the present invention comprising a cap with a plunger style opening mechanism;

Figure 2 is a mineral-fortification system similar to the one shown in Fig. 1 before the pouch is punctured;

Figure 3 is a pouch containing a mineral fortification powder according to the present invention;

Figure 4 is a mineral-fortification system according to the present invention comprising a cap with a screw-in-blade type opener;

Figure 5 is the mineral-fortification system of Fig. 4 after the pouch has been cut open;

Figure 6 is a mineral-fortification system according to the present invention comprising a cap wherein the pouch opener is adjacent the bottle rim;

Figure 7 is the mineral-fortification system of Fig. 6 after the pouch has been cut open;

Figure 8 is a mineral-fortification system according to the present invention comprising a cap wherein the pouch is a single layer barrier and the metal fortification powder is contained within a hollow plunger that acts as the pouch opener;

Figure 9 is a top view of the mineral-fortification system of Fig. 8 showing the protective cap that keeps the plunger from being prematurely depressed;

Figure 10 is a mineral-fortification system according to the present invention comprising a cap wherein the mineral fortification powder is contained within a plunger and the plunger bottom seals and protects the powder from the liquid below; and

Figure 11 is the mineral-fortification system of Fig. 10 showing the mineral fortification powder being released from the pouch within the cap as the plunger mechanism is depressed and the side opening of the plunger are exposed.

DETAILED DESCRIPTION OF THE INVENTION

As used herein, the term "comprising" means various components conjointly employed in the preparation of the liquid compositions of the present invention. Accordingly, the terms "consisting essentially of" and "consisting of" are embodied in the term "comprising".

As used herein, the terms "per serving", "per unit serving" or "serving size" refers to 250 milliliters of the finished beverage.

As used herein, all parts, percentages and ratios are based on weight unless otherwise specified.

The U.S. Recommended Daily Intake (USRDI) for vitamins and minerals are defined and set forth in the Recommended Daily Dietary Allowance-Food and Nutrition Board, National Academy of Sciences National Research Council, for a serving size of 250 mls of the liquid composition. As used herein, a nutritionally supplemental amount of minerals is at least about 5%, preferably from about 10% to about 200%, of the USRDI of such minerals. As used herein, a nutritionally supplemental amount of vitamins is at least about 5%, preferably from about 20% to about 200%, more preferably from about 25% to 100%, of the USRDI of such vitamins.

It is recognized, however, that the preferred daily intake of any vitamin or mineral may vary with the user. For example, persons suffering with anemia may require an increased intake of iron. Persons suffering from poor appetite, growth, performance and health may be suffering from mineral and vitamin deficiencies or who have poor diets will require more nutrients, for example, zinc, iodine, vitamin A, vitamin C and the B-vitamins (e. g. folate, B₁₂, B₆), particularly women of

child bearing age, physically active adults and growing children in developing countries. Such matters are familiar to physicians and nutritional experts, and usage of the compositions of the present invention may be adjusted accordingly.

Mineral Fortification System

Turning now to the drawings wherein Figure 1 is a mineral-fortification system 10 according to the present invention, which comprises cap 12 with plunger 14. Plunger 14 comprises barb 16, is adjacent plunger detent 22, and is slideably housed within cap housing 26. In Figure 1 cap 12 is shown on bottle 40 that contains liquid 42. Plunger detent 22 has been depressed by the consumer (not shown) pushing plunger 14 and plunger barb 16 through pouch membrane 19, which opens pouch 18 releasing fortification powder 20. Fortification powder 20 comprises a mineral supplement and a redox modulator, both of which are discussed in greater detail below. Fortification powder 20 may also contain the various optional ingredients discussed below. As shown in Figure 1 when pouch 18 is opened and the mineral fortification powder is released it will fall into liquid 42 where it can be mixed by slight agitation (for example, shaking of the bottle by the consumer) to form a mineral fortified liquid composition. Liquid 42 can be any liquid suitable for consumption by mammals, although water and water based liquids are preferred.

Figure 2 is a mineral-fortification system similar to that of Fig. 1 before the pouch is punctured. Note that in Figure 2 cap housing 27 of cap 13 is designed to sit on top of a bottle rather than sealing the bottle top by enclosing its neck. Cap 13 provides a mineral fortification system that can fortify a liquid in a variety of bottles because it is not constrained to any one bottle neck design and the threads or other enclosure devices associated therewith. Moreover, pouch 18 is shown in Figure 2 as being attached to cap 13, but this need not be the case.

Figure 3 shows a pouch 18 containing mineral fortification powder 20. As can be seen, pouch 18 can be a self contained, free standing unit that can be associated with or attached to either of cap 13 or bottle 40. Likewise, as shown in Figure 6, pouch 218 can be associated with neither cap 212 nor bottle 240, but is rather placed between them at the time of use.

Figure 4 shows yet another mineral-fortification system 110 according to the present invention comprising cap 112 with a blade 134 that cuts into pouch 118 when cap 112 is screwed onto package 141, via cap threads 130 and package threads 132. Blade 134 is associated with cap 112 but could easily be associated with the bottle as shown in Figures 6 and 7, wherein blade 234 is on bottle 240. Returning to Figures 4 and 5, package 141 can be a bottle, a jar, a juice box or any other appropriate container for liquid. Figure 5 illustrates the mineral-fortification system of Fig. 4 after pouch membrane 119 has been cut open by blade 134, dispensing mineral fortification powder 120 into liquid 142 to form the desired mineral fortified liquid compositions of the present invention.

Removable retaining ring 124, shown in Figure 4, is used to insure that pouch 118 cannot be opened prematurely. It is understood that one of the purposes of the present invention is to allow the consumer to mix, that is prepare, the mineral fortified liquid whenever he or she wishes. It can be seen that blade 134 does not penetrate pouch membrane 119 when cap 112 is first screwed onto package 141. Rather, cap 112 is screwed partially into package 141 with no contact between blade 134 and pouch membrane 119. Retaining ring 124 locks cap 112 into this pre-cutting position. Retaining ring 124 can be easily removed by pulling a tab or breaking a seal, and then removing the ring. Once retaining ring 124 is removed, cap 112 is further screwed onto package 141 allowing blade 134 to cut into pouch membrane 119 opening pouch 118. Thus, to insure that cap 112 is not screwed into package 141 before the consumer wants it to be, retaining ring 124 is attached to cap 112. Retaining rings are, of course, optional for the mineral fortification systems of the present invention, but they can be used with any of the embodiments shown herein.

As mentioned briefly above, Figures 6 and 7 illustrate a mineral-fortification system 210 according to the present invention comprising cap 212 wherein blade 234 is adjacent bottle 240. Moreover, pouch 218, comprising pouch membrane 219 and mineral fortification powder 220, is separate from bottle 240 and cap 212. As such, pouch 218 can be sold and shipped separately from cap 212, bottle 240 and liquid 242. Thus, pouch 218 can be placed on the open bottle 240 and cap 212 screwed onto bottle 240 via cap threads 230 and bottle threads 232. At some point before cap 212 is fully screwed onto bottle 240, blade 234 contacts and cuts pouch membrane 219 releasing mineral fortification powder 220 into liquid 242 as shown in Figure 7.

Turning now to Figure 8, which shows mineral-fortification system 310 according to the present invention comprising cap 312 with plunger 314. Plunger 314 comprises plunger barb 316,

plunger detent 322, and is slideably housed within cap housing 326. Further, plunger 314 comprises plunger hollow core 315 that can contain mineral fortification powder 320. In Figure 8 cap 312 is shown on bottle 340. When plunger detent 322 is depressed by the consumer (not shown), plunger 314 and plunger barb 316 are pushed through pouch membrane 319, which opens pouch 318 releasing fortification powder 320. In this embodiment pouch 318 comprises a single layer pouch membrane 319 and plunger hollow core 315. Fortification powder 320 comprises a mineral supplement and a redox modulator, both of which are discussed in greater detail below. Fortification powder 320 may also contain the various optional ingredients discussed below.

Mineral-fortification system 310 further comprises removable retaining cap 312 that protects plunger 314 from being depressed prematurely. Figure 9 is a top view of mineral-fortification system 310 showing removable retaining cap 312, retaining cap perforations 329 and retaining cap access 328. Retaining cap 325 can be removed by sticking and available implement, such as a finger tip, car key, etc., into retaining cap access 328, and applying an upward force sufficient to tear perforation 329. Once retaining cap 325 has been removed, plunger detent 322 can be pushed down causing plunger barb 316 to pierce and open pouch membrane 319 releasing mineral fortification powder 320.

Turning now to Figure 10, which shows yet another embodiment of the present invention, specifically, mineral-fortification system 410 comprising cap 412 with plunger 414. Plunger 414 comprises plunger detent 422 and pouch seal 421, and is slideably housed within cap housing 426. Further, plunger 414 comprises plunger hollow core 415 that can contain mineral fortification powder 420. When plunger detent 422 is depressed by the consumer (not shown), plunger 414 and pouch seal 421 slide within cap housing 426 allowing the hollow core edges 417 of plunger hollow core 415 to be exposed as pouch seal 421 is pushed beyond cap housing 426 as shown in Figure 11. When plunger hollow core edges 417 are exposed, pouch 418 is opened releasing fortification powder 420. Fortification powder 420 comprises a mineral supplement and a redox modulator, both of which are discussed in greater detail below. Fortification powder 420 may also contain the various optional ingredients discussed below.

The various components of the present systems, for example, caps, bottles, blades and plungers can be made from any of a variety of commonly available materials such as, plastic, glass, metal, paper, and laminates of these. The pouch membranes should be made of a material that is readily opened by the blade or plunger used to open the pouch. Moreover, the pouch membrane should not adversely affect the liquid after it is opened. For example, a glass pouch might be inappropriate for use herein if it breaks in a manner that leaves glass shards in the liquid. If, however, a portion of the pouch is made of glass and this portion remains intact after a different portion of the pouch membrane is cut, then there would be no contamination of the

liquid. This design, and many more that involve combinations of various materials, would be appropriate for use in the present invention. For a more detailed description of the component parts for use in the present system please see the following US Patents: 6,105,760, which issued to Mollstam et al. on August 22, 2000; 6,098,795, which issued to Mollstam et al. on August 8, 2000; 6,209,718, which issued to Mollstam et al. on April 3, 2001; 5,884,759, which issued to Gueret on March 23, 1999; 5,419,429, which issued to Zimmerman et al. on May 30, 1995, and 5,370,222, which issued to Steigerwald et al. on December 6, 1994. The disclosures of the Mollstam et al., Gueret, Zimmerman et al., and Steigerwald et al. references are incorporated herein in their entirety by reference.

Mineral Supplement Source

The mineral fortification systems of the present invention comprise a mineral fortification powder that comprises a mineral compound that is selected from the group consisting of calcium, iron, zinc, copper, manganese, iodine, magnesium, and mixtures thereof.

The mineral fortified liquid compositions of the present invention typically contain at least about 1 ppm of the mineral compound, or an amount sufficient to deliver about 5% to about 100% USRDI of the mineral (based per serving). Preferably the compositions contain from about 15% to about 50%, and most preferably about 20% to about 40% of the USRDI for the added mineral.

Iron Source

The iron compound of the present invention is selected from a water-soluble iron compound, a water-dispersible particulate iron compound, and mixtures thereof. In addition, the iron compound of the present invention is preferably selected from a complexed iron compound, a chelated iron compound, an encapsulated iron compound, and mixtures thereof. The iron compound should also be bioavailable to provide the health benefits herein before described.

A preferred iron compound can be added to a liquid to provide an iron-fortified liquid that reduces, and preferably eliminates the metallic taste and aftertaste that is typical of iron-containing waters and beverages. The elimination of the metallic taste can be achieved by encapsulating the iron compound. The metallic taste can also be eliminated by binding the iron into a stable compound by complexing or chelating with a suitable ligand that does not permit the iron to be freely associated in the water.

The inventors have discovered that a key factor in maintaining the stability of the ferrous state in a liquid is the control of the redox potential (reducing and oxidizing power) of the liquid. This work was done in an aqueous environment and the various ions compounds in water will undergo oxidation-reduction reactions, in an equilibrium state that is dictated by the redox

potential of the water system. In the case of iron, ferric iron (Fe^{3+}) can be reduced chemically to ferrous iron (Fe^{2+}) in an equilibrium state, if a redox potential of 770 mV or less is attained and maintained. Preferably, the redox potential is maintained below about 700 mV, more preferably below 500 mV, even more preferably below 300 mV, yet even below 200 mV, and most preferably below 150 mV.

Preferred iron compound forms also include encapsulates and complexes that have a dispersed particle size in the water that is small enough to be barely visible in solution. Preferably, the dispersed particle size is about 100 nanometers (nm) or less, and more preferably about 80 nm or less. A particularly preferred iron sources are inert and/or stabilized, micron-sized iron complexed with (a) pyrophosphate/orthophosphate as in SunActive iron (Taiyo Company, Japan) and (b) EDTA as in Na $\text{Fe}(\text{III})\text{EDTA}$.

A iron compound form useful for the purpose of the present invention is ferrous sulfate encapsulated in a hydrogenated soybean oil matrix, for example, CAP-SHURE, available from Balchem Corp., Slate Hill, N.Y., and chelated iron (i.e., ferrous) wherein the chelating agent is an amino acid, for example, FERROCHEL AMINO ACID CHELATE, available from Albion Laboratories, Inc., Clearfield, Utah. Other solid fats can be used to encapsulate the ferric sulfate, such as tristearin, hydrogenated corn oil, cottonseed oil, sunflower oil, tallow and lard.

Ferrous amino acid chelates particularly suitable as highly bioavailable amino acid chelated irons for use in the present invention are those having a ligand to metal ratio of at least 2:1. For example, suitable ferrous amino acid chelates having a ligand to metal mole ratio of two (2) are those of formula " $\text{Fe}(\text{L})_2$ ", where L is an alpha amino acid, dipeptide, tripeptide or quadrapeptide reacting ligand. Thus, L can be any reacting ligand that is a naturally occurring alpha amino acid selected from alanine, arginine, asparagine, aspartic acid, cysteine, cystine, glutamine, glutamic acid, glycine, histidine, hydroxyproline, isoleucine, leucine, lysine, methionine, ornithine, phenylalanine, proline, serine, threonine, tryptophan, tyrosine and valine or dipeptides, tripeptides or quadrapeptides formed by any combination of these alpha amino acids. See U.S. Patent 3,969,540 (Jensen), issued July 13, 1976 and U.S. Patent 4,020,158 (Ashmead), issued April 26, 1977; U.S. Patent 4,863,898 (Ashmead et al), issued September 5, 1989; U.S. Patent 4,830,716 (Ashmead), issued May 16, 1989; and U.S. Patent 4,599,152 (Ashmead), issued July 8, 1986, all of which are incorporated by reference. Particularly preferred ferrous amino acid chelates are those where the reacting ligands are glycine, lysine, and leucine. Most preferred is the ferrous amino acid chelate sold under the Trade name FERROCHEL by Albion Laboratories where the reacting ligand is glycine.

Ferrous iron is typically better utilized by the body than ferric iron. Highly bioavailable food grade ferrous salts that can be used in the present invention include ferrous sulfate, ferrous

fumarate, ferrous succinate, ferrous gluconate, ferrous lactate, ferrous tartrate, ferrous citrate, ferrous amino acid chelates, as well as mixtures of these ferrous salts. Certain ferric salts can also provide a highly bioavailable source of iron. Highly bioavailable food grade ferric salts are ferric saccharate, ferric ammonium citrate, ferric citrate, ferric sulfate, ferric chloride, as well as mixtures of these ferric salts.

Other bioavailable sources of iron particularly suitable for fortifying liquid of the present invention include certain iron-sugar-carboxylate complexes. In these iron-sugar-carboxylate complexes, the carboxylate provides the counterion for the ferrous (preferred) or ferric iron. The overall synthesis of these iron-sugar-carboxylate complexes involves the formation of a calcium-sugar moiety in aqueous media (for example, by reacting calcium hydroxide with a sugar, reacting the iron source (such as ferrous ammonium sulfate) with the calcium-sugar moiety in aqueous media to provide an iron-sugar moiety, and neutralizing the reaction system with a carboxylic acid (the "carboxylate counterion") to provide the desired iron-sugar-carboxylate complex. Sugars that can be used to prepare the calcium-sugar moiety include any of the ingestible saccharidic materials, and mixtures thereof, such as glucose, sucrose and fructose, marmose, galactose, lactose, and maltose, with sucrose and fructose being the more preferred. The carboxylic acid providing the "carboxylate counterion" can be any ingestible carboxylic acid such as citric acid, malic acid, tartaric acid, lactic acid, succinic acid, propionic acid, etc., as well as mixtures of these acids.

These iron-sugar-carboxylate complexes can be prepared in the manner described in U.S. Patents 4,786,510 and 4,786,518 (Nakel et al) issued November 22, 1988, both of which are incorporated by reference. These materials are referred to as "complexes," but they can, in fact, exist in solution as complicated, highly hydrated, protected colloids; the term "complex" is used for the purpose of simplicity.

The amount of iron compound added to the beverage dry mix can vary widely depending upon the level of supplementation desired in the final product and the targeted consumer. The USRDI for iron generally range from 10 mg per 6 kg female or male to 18 mg per 54-58 kg female, depending somewhat on age. The iron fortified compositions of the present invention typically contain at least about 1 ppm of iron compound, sufficient to deliver about 5% to about 100% USRDI of iron (based per serving) to account for iron that is available from other dietary sources (assuming a reasonably balanced diet). Preferably the compositions contain from about 15% to about 50%, and most preferably about 20% to about 40% of the USRDI for iron.

Zinc Source

The zinc compounds used in the present invention can be in any of the commonly used forms such as the sulfate, chloride, acetate, gluconate, ascorbate, citrate, aspartate, picolinate,

amino acid chelated zinc, as well as zinc oxide. It has been found, however, because of taste reasons, that amino acid chelated zinc sources are particularly preferred. The zinc-fortified composition of the present invention typically contains at least 5 ppm of zinc. Preferably, the liquid compositions contains zinc compound to provide about 5% to about 100% USRDI of zinc (based per serving) to account for that which is available from other dietary sources (assuming a reasonably balanced diet). Preferably the compositions contain from about 15% to about 50% and, preferably from about 25% to 40% of the USRDI for zinc.

The zinc compound can also be an encapsulated zinc compound, utilizing encapsulating materials described herein above for the iron compound.

Preferred zinc compound forms also include encapsulates and complexes that have a dispersed particle size in the water that is small enough to be barely visible in solution. Additionally, the preferred zinc sources are inert and/or stabilized, micron-sized zinc from zinc oxide in a dispersed particle size is about 100 nanometers (nm) or less, and more preferably about 80 nm or less.

Other Mineral Sources

Nutritionally supplemental amounts of other minerals for incorporation into the liquid composition include, but are not limited to, calcium, magnesium and copper. Any water-soluble salt of these minerals can be used, e.g., copper sulfate, copper gluconate, copper citrate and amino acid chelated copper. A preferred calcium source is a calcium citrate malate composition described in U.S. Patent 4,789,510, U.S. Patent 4,786,518 and U.S. Patent 4,822,847. Calcium in the form of calcium phosphate, calcium carbonate, calcium oxide and calcium hydroxide in micron-sized particles in a dispersed particle size is about 100 nanometers (nm) or less, and more preferably about 80 nm or less. Additional calcium sources include calcium citrate, calcium lactate and amino acid chelated calcium. Among the magnesium sources, the preferred are magnesium oxide and magnesium phosphate in micron-sized particles in a dispersed particle size is about 100 nanometers (nm) or less, and more preferably about 80 nm or less.

Redox Modulators

The mineral fortification systems of the present invention comprise a mineral fortification powder that comprises a redox modulating compound that is an electron donating/reducing compounds. These include redox modulator compounds that have the property (redox potential below that of ferric iron) of converting the oxidizing environment of regular water to reducing environment. Normally they have electron donating functional groups. These electron donating compounds keep (a) the iron in a reduced and soluble form, (b) prevent other minerals such as zinc from precipitating and (c) vitamins and flavors from degradation through the process of reducing the redox potential of the vehicle water. Such compounds are those with a redox

potential below that of ferric iron (770 mV). These may include ascorbic acid, ascorbyl palmitate, sodium bisulfite, erythorbic acid, sulfhydryl containing amino acids/peptides/proteins, polyphenols/flavonoids, soluble dietary fibers (e. g. arabinogalactan) as well as mixtures of these reducing agents. The preferred electron donating/reducing compounds are ascorbic acid, erythorbic acid and sodium bisulfites.

Mineral Chelating Compounds: These include ligands that have two or more electron donating groups. The preferred are EDTA, citrate, tartarate and polyphosphates.

Other Nutrients

The mineral fortification systems of the present invention comprise a mineral fortification powder that can optionally contain other nutrients in addition to minerals, for example vitamin C, vitamin E, vitamin A, niacin, thiamin, vitamin B6, vitamin B2, vitamin B 12, folic acid, selenium, pantathonic acid, iodine, and mixtures thereof.

Current USRDI values for most healthy adults are generally: vitamin C (60 mg), vitamin A as retinol (1 mg) or as β -carotene (3 mg), vitamin B₂ (1.7 mg), niacin (20 mg), thiamin (1.5 mg), vitamin B₆ (2.0 mg), folic acid (0.4 mg), vitamin B12 (6 μ g), and vitamin E (30 international units) and for iodine is 150 μ g.

The USRDI for calcium will range from 360 mg per 6 kg for infants to 1200 mg per 54-58 kg female, depending somewhat on age. Moreover, it can be difficult to supplement beverages with more than 20-30% USRDI of calcium (based per serving) without encountering precipitation and or organoleptic problems. However, this level of supplementation is equivalent to that provided by cow's milk, and is therefore acceptable.

Commercially available sources of vitamin C can be used herein. Encapsulated ascorbic acid and edible salts of ascorbic acid can also be used. Typically, from about 5% to about 200% of the USRDI of vitamin C is used in the liquid composition. Preferably from about 25% to about 150%, and most preferably about 100% of the USRDI for vitamin C is used in 35g of the liquid composition.

Commercially available vitamin A sources can also be incorporated into the liquid composition. A single serving preferably contains from about 5% to about 100% and most preferably contains about 25% of the USRDI of vitamin A. Vitamin A can be provided, for example, as vitamin A palmitate (retinol palmitate) and/or as beta-carotene. It can be as an oil, beadlets or encapsulated. As used herein, "vitamin A" includes vitamin A, β -carotene, retinol palmitate and retinol acetate.

Commercially available sources of vitamin B₂ (riboflavin) can be used herein. The resulting liquid composition preferably contains (per serving) from about 5% to about 200% and most preferably contains from about 15% to about 35% of the USRDI of vitamin B₂. Vitamin B₂

is also called riboflavin. Commercial sources of iodine, preferably as an encapsulated potassium iodide are used herein. Other sources of iodine include iodine containing salts, e.g., sodium iodide, potassium iodide, potassium iodate, sodium iodate, or mixtures thereof. These salts may be encapsulated.

Nutritionally supplemental amounts of other vitamins for incorporation into the liquid composition include, but are not limited to, vitamins B₆ and B₁₂, folic acid, niacin, pantothenic acid, folic acid, and vitamins D and E. Typically, the liquid composition contains at least 5%, preferably at least 25%, and most preferably at least 35% of the USRDI for these vitamins. Other vitamins can also be incorporated into the liquid composition depending on the nutritional needs of the consumers to which the water product is directed.

Coloring Agent

Small amounts of coloring agent, such as the FD&C dyes (e.g. yellow #5, blue #2, red #40) and/or FD&C lakes can be optionally used in the liquid or mineral fortification powder. Such coloring agents are added to the water for aesthetic reasons only, and are not required to mask an off color or precipitation caused by the iron compound. By adding the lakes to the other powdered ingredients, any particles, in particular any iron compound particles, are completely and uniformly colored and a uniformly colored beverage mix can be attained. Preferred lake dyes that can be used in the present invention are the FDA approved Lake, such as Lake red #40, yellow #6, blue #1, and the like. Additionally, a mixture of FD&C dyes or a FD&C lake dye in combination with other conventional food and food colorants can be used. The exact amount of coloring agent used will vary, depending on the agents used and the intensity desired in the finished product. The amount can be readily determined by one skilled in the art. Generally the coloring agent should be present at a level of from about 0.0001% to about 0.5%, preferably from about 0.004% to about 0.1% by weight of the dry powder. When the beverage is lemon flavored or yellow in color, riboflavin can be used as the coloring agent. P-carotene and riboflavin both contribute to the color of orange beverages.

Flavoring Agent

The liquid or mineral fortification powder can optionally comprise a flavoring agent consisting of any natural or synthetically prepared fruit or botanical flavors or with mixtures of botanical flavors and fruit juice blends. Such flavoring agents are added to the water for aesthetic reasons only, and are not required to mask an metallic taste or after-taste caused by the iron compound. Suitable natural or artificial fruit flavors include lemon, orange, grapefruit, strawberry, banana, pear, kiwi, grape, apple, lemon, mango, pineapple, passion fruit, raspberry and mixtures thereof. Suitable botanical flavors include jamaica, marigold, chrysanthemum, tea, chamomile, ginger, valerian, yohimbe, hops, eriodictyon, ginseng, bilberry, rice, red wine, mango, peony,

lemon balm, nut gall, oak chip, lavender, walnut, gentian, luohanguo, cinnamon, angelica, aloe, agrimony, yarrow and mixtures thereof. From about 0.01% to about 10%, preferably from about 0.02% to 8%, of these flavors can be used. Dry fruit juices can also be used as flavorants. The actual amount of flavoring agent will depend on the type of flavoring agent used and the amount of flavor desired in the finished beverage. Other flavor enhancers, as well as flavorants such as chocolate, vanilla, etc., can also be used.

Acid Component

An edible acid can optionally be added to the liquid composition of the present invention. Such flavoring agents are added to the water for aesthetic reasons only, and are not required to mask a metallic taste or after-taste caused by the iron compound. These acids may be used alone or in combination. The edible acid can be selected from tannic acid, malic acid, tartaric acid, citric acid, malic acid, phosphoric acid, acetic acid, lactic acid, maleic acid, and mixtures thereof.

Sweetener

The water of the present invention can optionally comprise a sweetener. Such flavoring agents are added to the water for aesthetic reasons only, and are not required to mask a metallic taste or after-taste caused by the iron compound. Suitable particulate sugars can be granulated or powdered, and can include sucrose, fructose, dextrose, maltose, lactose and mixtures thereof. Most preferred is sucrose. Artificial sweeteners can also be used. Often gums, pectins and other thickeners are used with artificial sweeteners to act as bulking agents and provide texture to the reconstituted dry beverage. Mixtures of sugars and artificial sweeteners can be used.

In addition to the added particulate sugar in the dry beverage mix, other natural or artificial sweeteners can also be incorporated therein. Other suitable sweeteners include saccharin, cyclamates, acesulfame-K, L-aspartyl-L-phenylalanine lower alkyl ester sweeteners (e.g. aspartame), L-aspartyl-D-alanine amides disclosed in U.S. Patent 4,411,925 to Brennan et al., L-aspartyl-D-serine amides disclosed in U.S. Patent 4,399,163 to Brennan et al., L-aspartyl-L-1-hydroxymethylalkaneamide sweeteners disclosed in U.S. Patent 4,338,346 to Brand, L-aspartyl-1-hydroxyethylalkaneamide sweeteners disclosed in U.S. Patent 4,423,029 to Rizzi, L-aspartyl-D-phenylglycine ester and amide sweeteners disclosed in European Patent Application 168,112 to J. M. Janusz, published January 15, 1986, and the like. A particularly preferred optional and additional sweetener is aspartame.

Antioxidant

The liquid or mineral fortification powder can further comprise a food grade antioxidant in an amount sufficient to inhibit oxidation of the aforementioned materials, especially lipids. Excessive oxidation can contribute to off-flavor development of these ingredients. Excessive

oxidation can also lead to degradation and inactivation of any ascorbic acid or other easily oxidized vitamin or minerals in the mix.

Known or conventional food grade antioxidants can be used. Such food grade antioxidants include, but are not limited to, butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and mixtures thereof. Selection of an effective amount of a food grade antioxidant is easily determined by the skilled artisan. Limitations on such amounts or concentrations are normally subject to government regulations.

Preparation of the liquid composition

The liquid compositions of the present invention can be prepared from a variety of liquid sources. Most preferred are deionized water, softened water, or distilled water.

The present invention provides a process step wherein fortification of water with minerals and vitamins is accomplished without the development of undesirable color, solubility, flavor and bioavailability through redox modulation, which in this case is reducing the redox potential. A preferred treatment comprises removing and/or scavenging the main species in water that contributes to its high redox potential, which is the dissolved oxygen. The process includes deoxygenating the water to reduce the concentration of oxygen in the water, or to eliminate all dissolved oxygen. Preferred methods of deoxygenating the water include stripping of oxygen (and other dissolved gases) with carbon dioxide or other inert gas. Preferred as inert gases, such as nitrogen gas. Oxygen gas can also be reduced by heating the water to high temperatures, at which the solubility is reduced. Another method comprises adding reducing agents to the water, such as ascorbic acid. The oxygen level in the source water is typically reduced to less than 5 ppm, preferably less than 3 ppm, and more preferably less than 1 ppm.

The deoxygenation process typically also removes other redox potential increasing agent, such as any halide gas, like chlorine gas, as well as volatile organic materials. Additionally, the water used is treated to have minimal amount of the other electron acceptors that have greater redox potential than that of iron. These include ozone, chloride and hypochlorates, nitrates and nitrites as well as manganese (IV).

The mineral compound, is then admixed at the desired nutrient level, typically under mild stirring. Preferably, the admixing step is conducted under an inert gas blanket to exclude outside air and oxygen from the product.

Finally, the water is packaged into glass or plastic bottles, or other suitable container. Preferably, the plastic material of the bottle is an oxygen-impermeable barrier.

EXAMPLES

The following are non-limiting examples of mineral fortification powders that can be use in the pouch of the mineral fortification systems of the present invention. The mineral fortification powders are prepared utilizing conventional methods. The following examples are provided to illustrate the invention and are not intended to limit the scope thereof in any manner.

Example 1

A mineral fortification powder is prepared having the following ingredients in the indicated amounts:

Ingredient	Amount
SunActive Iron (8.0% Fe)	1.8 mg
Zinc bis-glycinate (21.8% Zn)	1.5 mg
Vitamin C as sodium ascorbate (88.9% Vit.C)	60 mg
Vitamin B6	0.2 mg
Vitamin B12 (1% Vit.B12)	0.6 microgm
Citric Acid	.01 gm
Folic Acid	40 microgm

Upon preparing the mineral fortification powder, it is placed in a sealed pouch and inserted into a cap as shown in Figure 1. The cap is then placed on a bottle of Reverse Osmosis/Millipore (Milli-Q) water and the plunger is depressed. The bottle of water is gently swirled to mix the powder and to make a fortified liquid composition that has no off-color or rusty color, no precipitation or turbidity, and low redox potential. The taste of the liquid composition is not significantly different in metallic taste or after-taste when compared to the liquid vehicle alone (Reverse Osmosis/Millipore (Milli-Q) Water).

Example 2

A mineral-fortified liquid composition according to the present invention, and more specifically, according to Example 1, was compared to common tap water, distilled water treated by a common Reverse Osmosis process, and a variety of commercially available bottle waters. Some of the commercially available bottled waters were supplemented with vitamins. Using the measure values for the Redox potential (listed as "mV" in Table 2A) and pH, the inequality $0 \geq$

RP – (A - B*pH) was calculated for various values of “A” and “B”. The results of these calculations are given in Table 2A. Table 2B gives additional data from the comparison of these products.

TABLE 2A

			<u>A = 400</u>	<u>A = 380</u>	<u>A = 360</u>	<u>A = 340</u>
	<u>mV</u>	<u>PH</u>	<u>B = 20</u>	<u>B = 18</u>	<u>B = 16</u>	<u>B = 14</u>
Water of Example 1	192	4.85	-111	-101	-90	-80
Tap water	316	8.95	95	97	99	101
Reverse Osmosis water	360	5.75	75	84	92	101
Fresh milliQ ¹	320	6.52	50	57	64	71
Stored milliQ	336	5.74	51	59	68	76
Aquafina Plus Calcium ²	403	4.21	87	99	110	122
Aquafina Multi-V	365	3.96	44	56	68	80
Aquafina Daily C	338	4.04	19	31	43	55
Hansen Energy ³	406	3.76	81	94	106	119
Propel Fitness ⁴	384	3.47	53	66	80	93
Reebok Fitness ⁵	432	3.12	94	108	122	136
Glacéau Fruitwater ⁶	427	3.47	96	109	123	136

TABLE 2B

	<u>Dissolved</u>		<u>Hunter</u>
	<u>Oxygen</u>	<u>Turbidity</u>	<u>"b"</u>
Water of Example 1	1.15	0.643	-0.12
Tap water	8.02	0.447	-0.24
Reverse Osmosis water	6.51	0.4	-0.26
Fresh milliQ ¹	4	0.435	-0.26
Stored milliQ	9.29	0.476	-0.23
Aquafina Plus Calcium ²	1.15	0.492	-0.24
Aquafina Multi-V	0.22	7.48	-0.12
Aquafina Daily C	0.17	0.612	-0.14
Hansen Energy ³	7.06	0.671	-0.25
Propel Fitness ⁴	5.69	4.96	-0.17
Reebok Fitness ⁵	3.63	0.575	-0.17
Glaceau Fruitwater ⁶	7.47	0.628	-0.24

¹MilliQ is analytical distilled reverse osmosis water from Millipore Academic Ultrapure water purification system

²Aquafina is a commercially available bottled water product produced by Pepsi

³Hansen Energy is a commercially available bottled water product produced by Hansen Beverage Company

⁴Propel Fitness is a commercially available bottled water product produced by The Gatorade Company

⁵Reebok Fitness is a commercially available bottled water product produced by Cleary Canadian Beverage Corporation

⁶Glaceau Fruitwater is a commercially available bottled water product produced by Energy Brands, Inc.

MINERAL FORTIFICATION SYSTEMS

What is claimed is:

1. A mineral-fortification system characterized in that it comprises:

- a) a bottle cap comprising a pouch and a pouch opener;
- b) a powder contained within the pouch, the powder comprising at least one mineral and a redox modulating compound; and

wherein when the cap is secured onto the opening of a bottle containing a liquid and when the pouch opener is activated, the powder is released from the pouch and mixes with the liquid to form a mineral fortified liquid composition that is fortified with the at least one mineral and has a pH between 2.5 and 9.5, and the mineral fortified liquid composition has a redox potential that satisfies the following equation:

$$0 \geq RP - (A - B \cdot pH)$$

wherein RP is the measured redox potential in millivolts of the mineral fortified liquid composition, pH is the pH of the mineral fortified liquid composition, A is 400 and B is 20, preferably A is 380 and B is 18, more preferably A is 360 and B is 16, and even more preferably A is 340 and B 14.

2. The mineral-fortification system of Claim 1, wherein the mineral is selected from the group consisting of calcium, iron, zinc, copper, manganese, iodine, magnesium, and mixtures thereof.

3. The mineral-fortification system of either of Claims 1 or 2, further comprising a container containing a liquid, and preferably the liquid contained within the bottle comprises less than 3 ppm oxygen, and even more preferably the liquid comprises at least 90%, preferably at least 95%, and more preferably at least 99%, by weight, water.

4. The mineral-fortification system of Claims 1, 2 or 3, wherein the mineral fortified liquid composition is substantially free of a flavor or sweetener compound, and wherein the liquid composition has:

- not significantly different from water in metallic taste or after-taste,
- a Hunter colorimetric "b" reading of less than 5.0, and
- an NTU turbidity value of less than 5.0.

5. The mineral-fortification system of Claims 1, 2 or 3, wherein the mineral is a water-dispersible compound having a dispersed particle size of less than 100 nanometers.
6. The mineral-fortification system of Claims 1, 2 or 3, wherein the pouch opener comprises a blade that cuts into and opens the pouch when the cap is twisted onto a bottle, and preferably the cap further comprises a removable retaining ring that protects the pouch from being opened prematurely.
7. The mineral-fortification system of Claims 1, 2 or 3, wherein the pouch opener comprises a plunger that opens the pouch when it is pressed down and through the pouch and preferably the cap further comprises a removable retaining ring that protects the pouch from being opened prematurely.
8. The mineral-fortification system of Claim 1, wherein the liquid further comprises a redox potential lowering agent, and preferably the liquid further comprises less than 3 ppm dissolved oxygen gas, and even more preferably, the liquid is substantially free of a redox potential increasing agent selected from an oxoanion salt, a halide gas, nitrates and minerals such as manganese in oxidized state.
9. The mineral-fortification system of any of the preceding claims, wherein at least one of the minerals is an iron compound selected from the group consisting of a water-soluble iron compound, a water-dispersible particulate iron compound, and mixtures thereof, preferably the iron compound is selected from the group consisting of a complexed iron compound, a chelated iron compound, an encapsulated iron compound, and mixtures thereof.
10. The mineral-fortification system of any of the preceding claims, further comprising at least 2 ppm of a zinc compound selected from the group consisting of a complexed zinc compound, a chelated zinc compound, and an encapsulated zinc compound, and mixtures thereof.
11. The mineral-fortification system of any of the preceding claims, wherein the powder further comprises an additive selected from the group consisting of vitamin A, vitamin C, vitamin E, niacin, thiamin, vitamin B6, vitamin B2, vitamin B 12, folic acid, selenium, pantathonic acid, iodine and mixtures thereof.

12. The mineral-fortification system of Claim 3, wherein the container is an oxygen-barrier package, and is preferably a bottle.

1/7

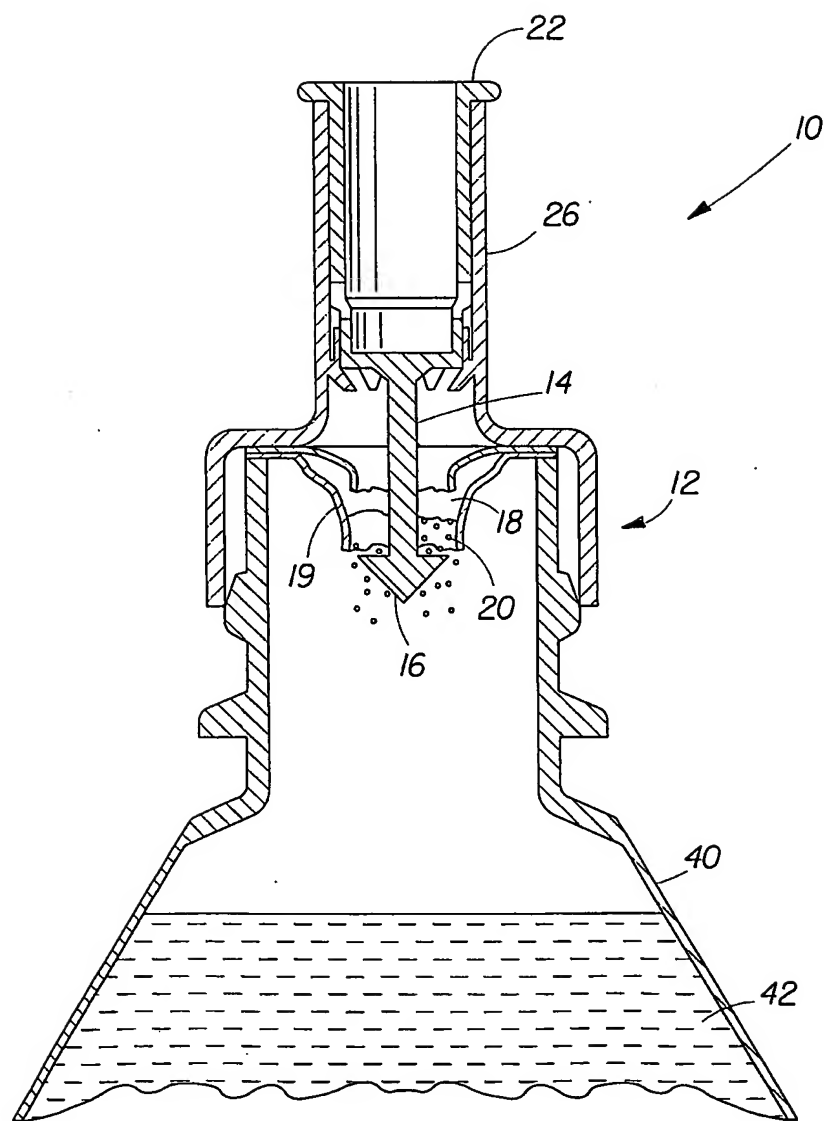


Fig. 1

2/7

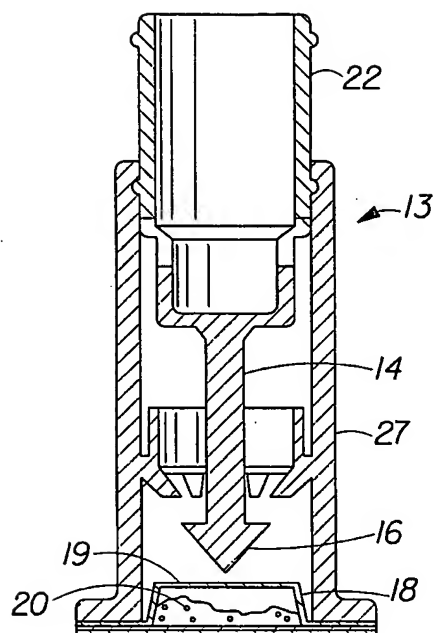


Fig. 2

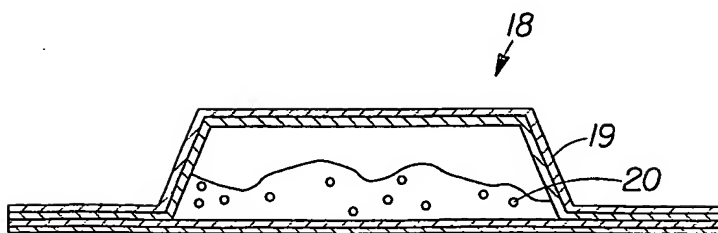


Fig. 3

3/7

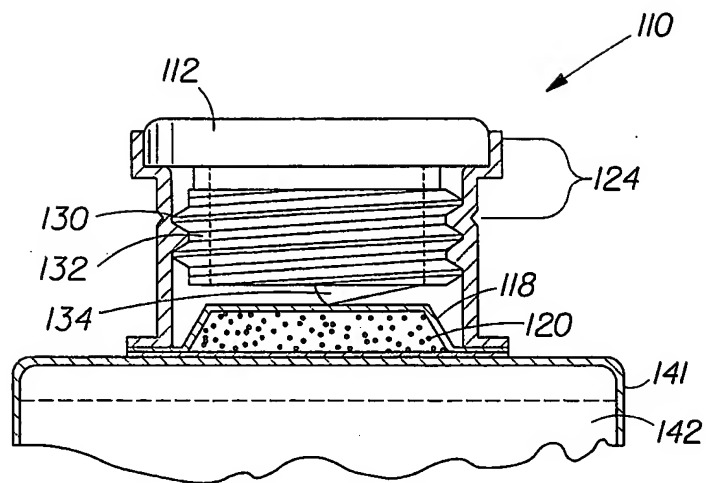


Fig. 4

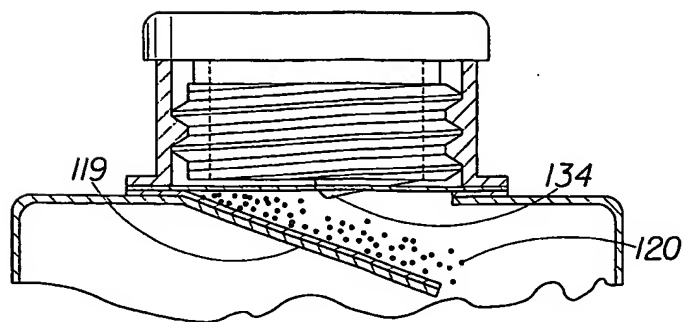
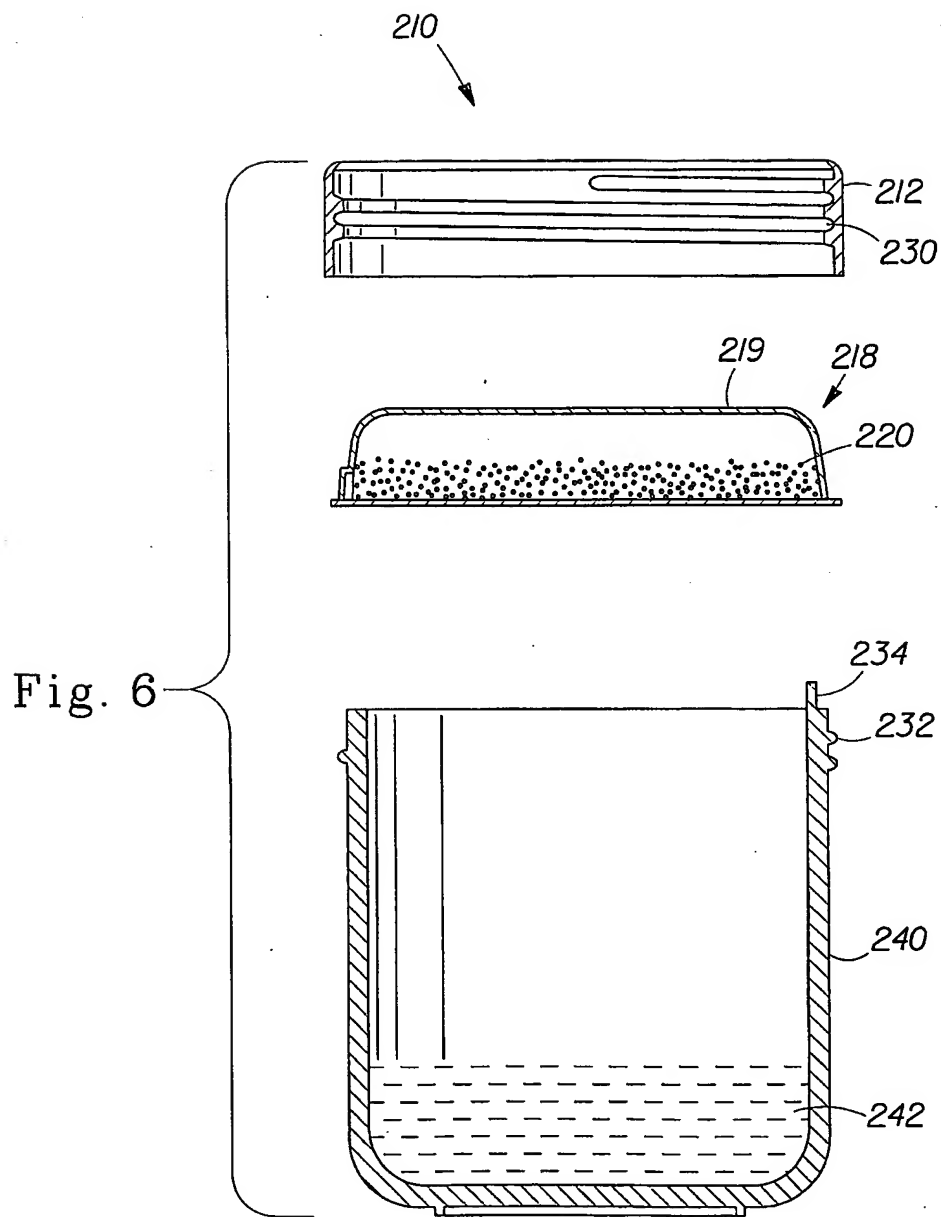


Fig. 5

4/7



5/7

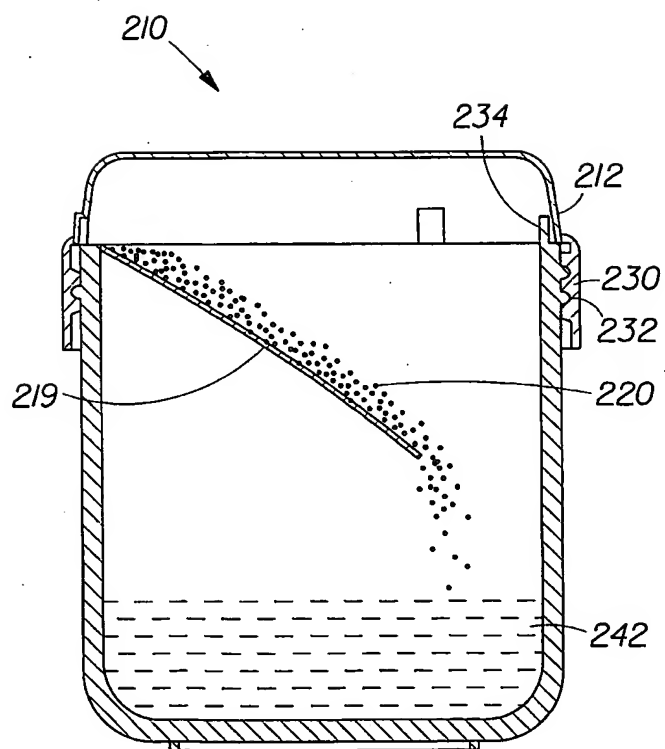


Fig. 7

6/7

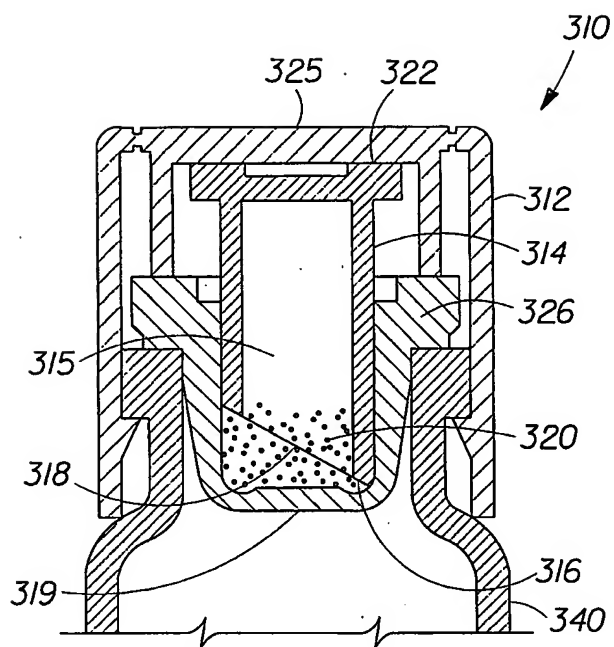


Fig. 8

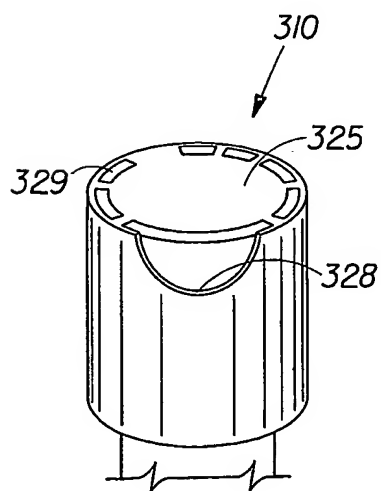


Fig. 9

7/7

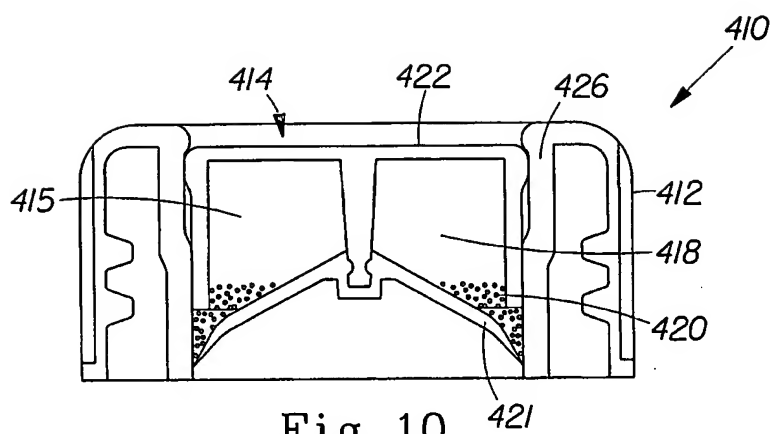


Fig. 10

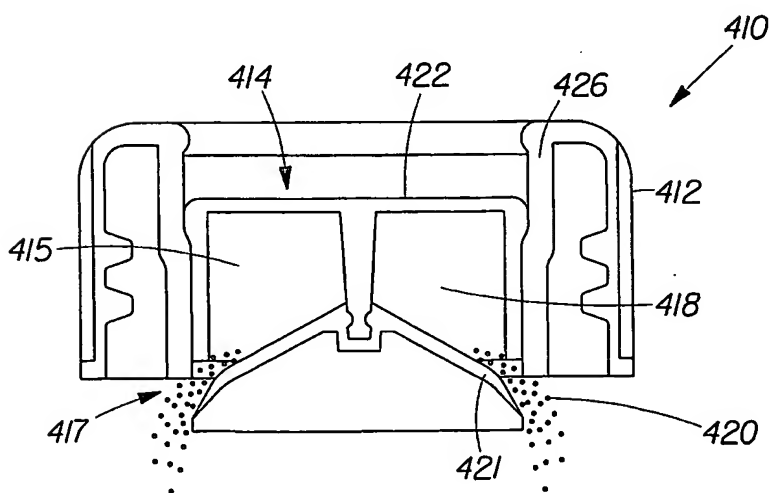


Fig. 11

INTERNATIONAL SEARCH REPORT

Internat Application No
PCT/US 03/15423

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B65D51/28 B65D81/32 A23L2/52 A61K33/26 A61K33/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B65D A23L A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, FSTA, MEDLINE, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,P	WO 02 096225 A (PROCTER & GAMBLE) 5 December 2002 (2002-12-05) page 1; claims 1-10 ---	1-12
A	WO 98 48648 A (HENRY WILLIAM JOHN JR ;MELICAN RENEE IRVINE (US); XI XIAOBING (US) 5 November 1998 (1998-11-05) cited in the application claims 1,2,11-13,30 ---	1-12
A	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 12, 26 December 1996 (1996-12-26) -& JP 08 217157 A (NIKKO SEIKA KK), 27 August 1996 (1996-08-27) abstract; figure 1 --- -/--	1,6,7

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *G* document member of the same patent family

Date of the actual completion of the international search

5 September 2003

Date of mailing of the international search report

12/09/2003

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Groh, B

INTERNATIONAL SEARCH REPORT

Internat^l Application No

PCT/JP 03/15423

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 2002, no. 08, 5 August 2002 (2002-08-05) -& JP 2002 114259 A (BEST WORLD:KK), 16 April 2002 (2002-04-16) abstract; figure 1 -----	1,6,7
A	US 4 032 029 A (COCHRANE BENJAMIN ARTHUR) 28 June 1977 (1977-06-28) column 2, line 15 - line 21; figures 2-10 -----	6,7

INTERNATIONAL SEARCH REPORT
if
in on patent family members

International application No
PCT/LU J3/15423

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 02096225	A	05-12-2002	WO 02096225 A2	05-12-2002
			US 2003049352 A1	13-03-2003
WO 9848648	A	05-11-1998	WO 9848648 A1	05-11-1998
			AU 2816397 A	24-11-1998
			CA 2278536 C	31-12-2002
			EP 0969747 A1	12-01-2000
			US 6358544 B1	19-03-2002
			AT 222711 T	15-09-2002
			AU 7455996 A	15-05-1997
			BR 9611253 A	30-03-1999
			CA 2235618 C	03-09-2002
			CA 2395330 A1	01-05-1997
			CN 1202804 A ,B	23-12-1998
			DE 69623326 D1	02-10-2002
			DE 69623326 T2	15-05-2003
			DK 871378 T3	07-10-2002
			EP 0871378 A1	21-10-1998
			ES 2178719 T3	01-01-2003
			JP 11511337 T	05-10-1999
			JP 3288714 B2	04-06-2002
			PL 326389 A1	14-09-1998
			PT 871378 T	29-11-2002
			RU 2197873 C2	10-02-2003
			WO 9715201 A1	01-05-1997
			US 2002064578 A1	30-05-2002
			US 2002061347 A1	23-05-2002
			US 2002058088 A1	16-05-2002
JP 08217157	A	27-08-1996	NONE	
JP 2002114259	A	16-04-2002	NONE	
US 4032029	A	28-06-1977	CA 1047969 A1	06-02-1979
			DE 2714616 A1	20-10-1977
			FR 2347272 A1	04-11-1977
			GB 1525534 A	20-09-1978
			JP 52121485 A	12-10-1977
			NL 7703154 A	07-10-1977